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THE TAXONOMIC POSITION OF THE MODERN SEA-STAR *CISTINA* GRAY, 1840

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Abstract.—The taxonomic position of the sea-star *Cistina columbiae* Gray, 1840, has been uncertain because it possesses characters which allow its referral to two different families, as presently conceived. A reevaluation, stressing skeletal morphology, strongly indicates ophidiasterid affinities, as originally suggested by Gray.

Introduction

Gray (1840) included his new genus and species *Cistina columbiae* with genera now assigned to the Ophidiasteridae. Because *C. columbiae* bears a small spine on the primary abactinal and marginal ossicles, a feature otherwise unknown among ophidiasterid genera, its taxonomic position has been questioned (H. L. Clark, 1921) and the genus recently has been included in the family Echinasteridae (A. M. Clark and Rowe, 1971). Assignment has remained difficult because the genus has been only rarely encountered, hence adequate material for comparative study has not been available.

Miss A. M. Clark [British Museum (Natural History)] brought this taxonomic problem to the attention of the writer, and very kindly made a specimen of *C. columbiae* available for dissection and study.

In evaluating the ossicle morphology of the ambulacral column, I became convinced that Gray was correct in his assessment of affinities and that *Cistina* indeed is an ophidiasterid. Further studies at the U.S. National Museum of Natural History revealed that *Cistina* is very close to *Leiaster*, a fact suggested by the close placement of the two genera in H. L. Clark's key (1921:37).

It is therefore recommended here that *Cistina* be returned to the Ophidiasteridae and assigned a position near *Leiaster*. The two genera are here compared with each other and with *Echinaster*, and a diagnosis of *Cistina columbiae* is provided.

Materials and Methods

Specimens studied included the following:

Cistina columbiae Gray, 1840, BM(NH) 86.12.29.4; Mauritius; R range = 48–85 mm, r = 9 mm.

Leiaster teres Verrill, 1871, USNM 39991; Gulf of California; R = 90 mm, r = 13 mm.

Echinaster modestus Perrier, 1881, University of Illinois, Department of Geology; west coast of Florida; 10 specimens, ossicles from specimen $R = 60$ mm, $r = 12$ mm.

Arm fragments were manually broken from the specimens; disc fragments were removed using a high speed rotary hand tool with a cutting disc. Such a tool permits removal of fragments with very little vibration and specimen distortion, hence minimizing the chances for ossicle breakage. In spite of this procedure, ossicles commonly are found to be broken once the flesh has been cleared (e.g., Fig. 2 row C, middle). Study of untreated, dried specimens frequently reveals ossicles already broken; tissue shrinkage associated with drying apparently can pull ossicles apart, especially where these structures are relatively fragile and the tissues thick.

Ossicles were isolated through treatment in sodium hypochlorite (common household bleach). Drawings were prepared through the use of photographic negatives and an enlarger; shading was based on prints from the negatives. In preparation for photography, ossicles and the arm of *Echinaster* were first painted with dark ink, dried, then coated with ammonium chloride. Arm fragments of *Leiaster* and *Cistina* were not ink-painted because the thick skin layer does not absorb ink, resulting in an irregular coloring and poor photographs.

Comparative Morphology of *C. columbiae* (C.), *L. teres* (L.), and *E. modestus* (E.)

1. Arrangement of abactinal ossicles, marginals
   - L. all in regularly defined longitudinal rows, overlapping in proximal direction
   - C. rows more or less regularly defined, otherwise as L.
   - E. abactinals in more or less irregular, longitudinal rows; marginals in regular rows; all series overlapping in the distal direction
2. Morphology of primary abactinals (see Fig. 2, row a)
   - L., C. flattened, cross-shaped
   - E. weakly inflated, bearing small articulation facets
3. Encrusting ossicles on primary abactinals
   - L. absent
   - C.,E., short spines
4. Secondary abactinals and papulae distribution
   - L., C. secondaries in well-defined rows, separating well-defined rows of papulae
   - E. secondaries scattered, papulae irregular in distribution
5. Intermarginals[1]
   - L. on arms, single row of rod-like ossicles reaching or nearly reaching arm tip; few extra ossicles probably present interbrachially

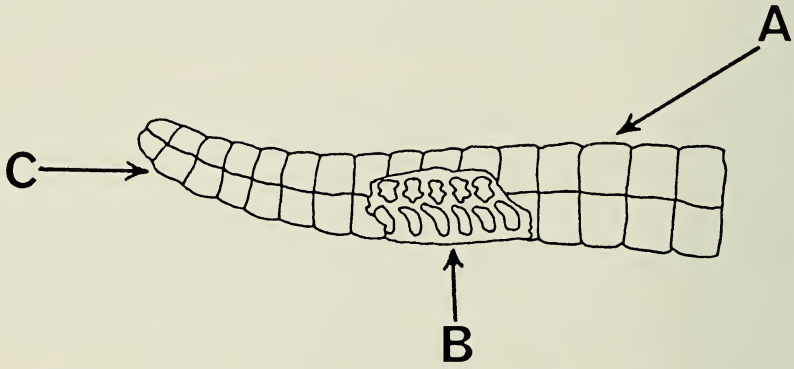

Fig. 1. Stylized lateral view of sea-star arm showing orientation of drawings of ambulacrals and adambulacrals in Figs. 2, 3. Marginals have been removed medially to show positions and orientation of ambulacrals (above) and adambulacrals (below).

C. arm development as in L.; interbrachial region not clearly observed, but space available for few added intermarginals

E. single irregular row originating about ¼ distance from arm tip, increasing to numerous somewhat irregularly arranged interbrachial series, these ossicles largely actinal in position on disc

6. Interactinals[1]

L., C. two rows, abactinal row similar to secondary abactinals; actinal row ossicles flat, overlapping

E. lacking, or few ossicles present immediately radial to oral ossicles

7. Adambulacral form (see Fig. 3)

L., C. adradial ossicle tip directed distally as flange (Fig. 3:1); furrow armature longitudinally arranged

E. adradial ossicle tip directed into furrow (Fig. 3:1); furrow armature radially arranged

8. Adambulacral articulation (Fig. 3)

a. L., C. inter-adambulacral muscle depression on proximal face high, triangular (Fig. 3:2)

E. inter-adambulacral muscle depression on proximal face low, elliptical (Fig. 3:2)

b. L., C. interadambulacral contact structures developed as distinct adradial process and a low transverse ridge rather sharply set off from adambulacral-ambulacral articulation structures (Fig. 3:3)

E. interadambulacral contact structures developed as a transverse ridge, forming the base of a broad, V-shaped ridge continuous with adambulacral-ambulacral articulation structures (Fig. 3:3)

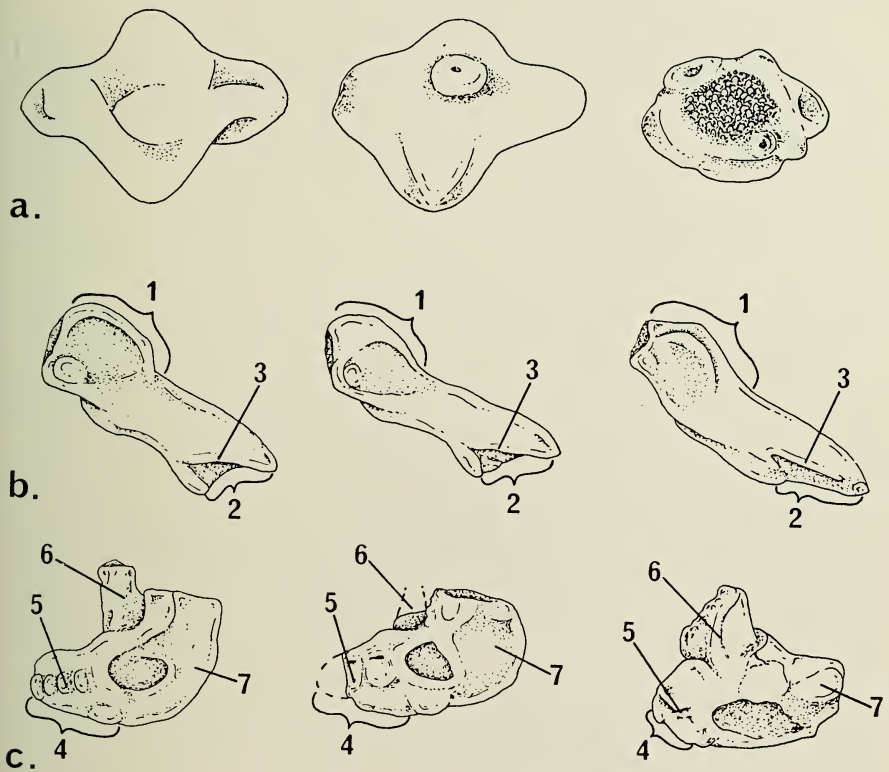

Fig. 2. Ossicle morphology of *L. teres* (left column), *C. columbiae* (middle column) and *E. modestus* (right column). Row a, abactinals in oblique abactinal view; spine bases present on *columbiae*, *modestus*, glassy granules on *modestus*. Row b, ambulacrals in proximal view (C in Fig. 1), furrow left. 1. Adradial articulation flanges; 2. Ambulacral-adambulacral articulation structures; 3. Muscle wings. Row c, oral ossicles in furrow view, mouth to left, actinal down; 4. Proximal tip; 5. Spine base row; 6. First ambulacral articulation flange; 7. Distal flange. Dotted lines on *Cistina* are reconstructions based on fracture surfaces visible on ossicles.

c. L., C. adambulacral-ambulacral contact structures developed as two distinct, prominent, subcircular processes (Fig. 3:4)

E. adambulacral-ambulacral contact structures developed as the vertical arms of a broad U-shaped ridge (Fig. 3:4)

9. Ambulacral morphology (see Fig. 2, row b)

a. L., C. adradial articulation structures on a prominent flange, sharply set off from remainder of ossicle; flanges strongly overlap next proximal ambulacral (Fig. 2:1)

E. adradial articulation structures on a low flange, gradational with remainder of ossicle; flanges weakly overlap next proximal ambulacral (Fig. 2:1)

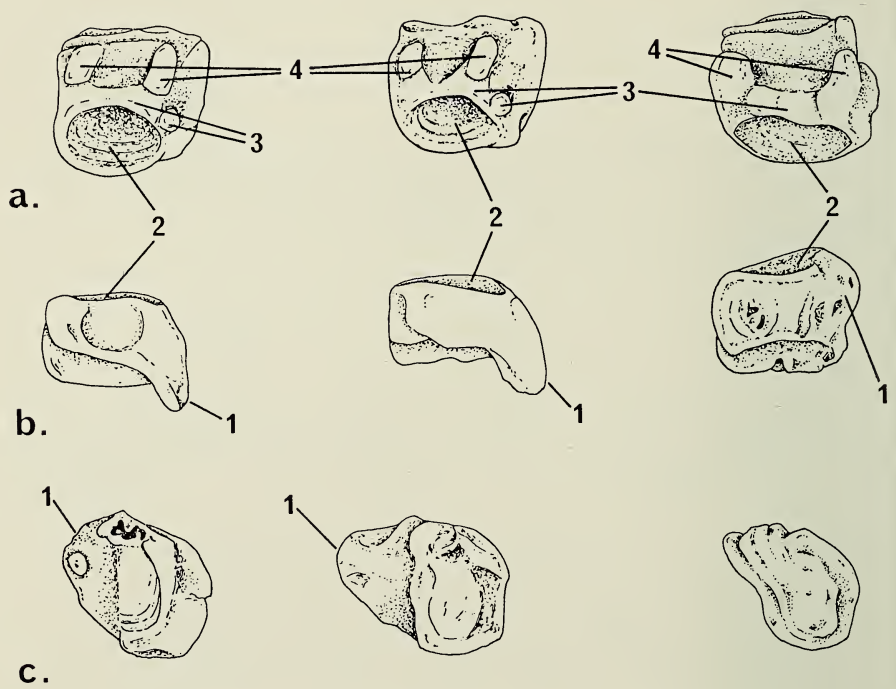

Fig. 3. Ossicle morphology of *L. teres* (left column), *C. columbiae* (middle column) and *E. modestus* (right column). Adambulacrals from left side of arm, row a, oblique proximal view (A, Fig. 1); row b, actinal view (B, Fig. 1); row c, abradial view (normal to Fig. 1); furrow right in a, b; down in c. Key: 1. Adradial flange, distally directed; 2. Interadambulacral muscle depression; 3. Interadambulacral articulation facets; 4. Adambulacral-ambulacral articulation facets.

b. L., C. ambulacral-adambulacral articulation structures developed as narrow, high surface, the actinal margin of the surface and the articulation wings more or less steeply inclined to the ossicle axis (Fig. 2:2, 3)

E. ambulacral-adambulacral articulation structures developed as broad, low surface, the actinal margin of the surface and the articulation wings oriented subparallel to the ossicle axis (Fig. 2:2, 3)

10. Orals[2] (see Fig. 2, row c)

a. L., C. proximal ossicle tip triangular, attenuated; bearing prominent spine base row (Fig. 2:4, 5)

E. proximal ossicle tip short, broadly triangular; spine base row not prominent (Fig. 2:4, 5)

b. L., C. first ambulacral articulation bar approximately medially placed (Fig. 2:6)

E. first ambulacral articulation bar placed proximal of medial (Fig. 2:6)
c. L. distal portion of ossicle developed as a high, prominent flange (Fig. 2:7)
C. distal portion of ossicle developed as moderately high flange (Fig. 2:7)
E. distal portion of ossicle developed as a low flange (Fig. 2:7)

Family OPHIDIASTERIDAE Verrill, 1867
Genus CISTINA Gray, 1840
Cistina columbiae Gray, 1840
Plate 1, figs. 1a–1d; Figs. 2, 3, middle columns

Echinaster sladeni de Loriol, 1893

Rays cylindrical, 5 in number, somewhat stout for family, of varied lengths, tips blunt; disc relatively small. Body covered by fairly thick skin which can be reddish brown when dried. Papulae arranged in longitudinal rows between secondary abactinals, intermarginals, and abactinal row of interactinals. Marginals and primary abactinals morphologically similar, arranged in 7 fairly well-defined longitudinal rows (3 abactinal, 4 marginal); individual ossicles flat, generally bearing 4 flanges that overlap adjacent secondary ossicles and next proximal ossicle of primary series. Generally 1, occasionally more short stout spines borne medially on ossicle; spine base circular, inflated; remainder of surface without encrusting ossicles. Secondary ossicles flattened, transversely elongate, separated from one another by gaps for papulae; secondaries link and are overlapped by primary series. Interactinals in 2 series; row below inframarginals similar to secondary abactinals; row adjacent to adambulacrals simple flat discs, overlapping proximally. Secondary abactinals, interactinals lack encrusting ossicles. Adambulacral ossicle actinal surfaces rectangular in outline, closely spaced along arm. Furrow spines short, tapered, columnar, not grooved, arranged in single longitudinal row on arm, 2 spines on each adambulacral. Sub-ambulacral spines longer, tapered, columnar, arranged in single longitudinal row, 1 on each adambulacral proximally, gradually reduced to 1 on alternate adambulacrals distally. Individual adambulacrals rectangular in side face outline, bearing prominent distally deflected furrow flange. Ambulacral ossicles bearing prominent adradial, proximally directed muscle flange for articulation with next proximal ambulacral. Oral ossicles bear attenuated, triangular proximal tip; prominent spine bases; approximately medially placed first adambulacral articulation bar.

Remarks.—Gray (1840:283) reports the type-material of *Cistina columbiae* from the west coast of Colombia; unfortunately, the location of the types is unknown (Clark, 1921:71; Clark & Rowe, 1971:72). Clark and Rowe

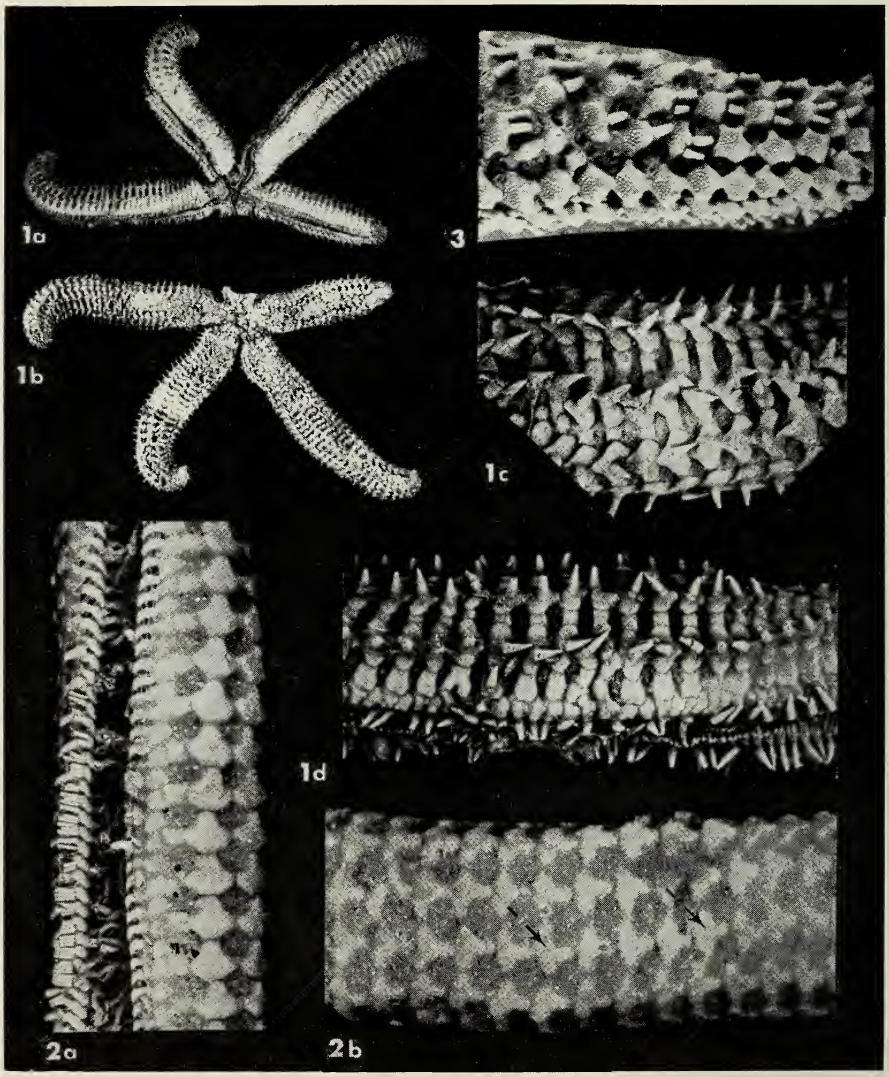

Plate 1. 1. *C. columbiae.* a, b, Abactinal, actinal views, overall form of species, ×4; c, Lateral view of arm, marginals below, lateral row of abactinals, carinals, secondary abactinals above, ×2; d, Ventrolateral view, marginals, interactinals, furrow area, ×2½. 2. *L. teres.* a, Ventrolateral view, marginals, interactinals, furrow area, ×2; b, Abactinal view, carinals (arrow), laterals, supramarginals, ×2. 3. *E. modestus*, lateral view, double row of marginals below, irregular distribution of abactinals, ×3.

(1971), in comparing Gray's and de Loriol's descriptions to the specimen studied here, place *E. sladeni*, the types of which are from Mauritius, in synonymy with *C. columbiae.* They further argue that the *Cistina* type-material probably also was from Mauritius, source of much of Gray's

material. The available specimen does closely fit Gray's description, including the presence of 7 rows of spines on the arms, a critical feature leading to the taxonomic difficulties considered here.

Acknowledgments

I am indebted to Miss Ailsa M. Clark for bringing the problem to my attention and for making a specimen of *C. columbiae* available; to Ms. Maureen E. Downey for reviewing the manuscript and making available a specimen of *Leiaster teres* Verrill; to Mr. Edward Snyder (University of Illinois) for preparation of drawings, and to Ms. Danita Brandt (University of Illinois) for other technical assistance. Research was supported in part through NSF BMS 75-19427.

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Footnotes

[1] Identification of marginals, and hence recognition of intermarginal and interactinal series can be difficult in those sea stars, such as the three under discussion here, that lack marginals clearly differentiated in either size or morphology. It is my opinion, however, that almost invariably in the sea-stars a double series of ossicles arises near the actinal lateral margin of each side of the terminal, and that this series can be traced along the arm, recognizable through position and alignment, size, or morphology, or some combination of these criteria. I believe marginals can be recognized in the taxa under consideration, and hypothesize that the marginal series are homologous as a differentiated arm framework (a hypothesis presumably testable by ontogenetic studies) and the intermarginal and interactinal series evaluations were based on these conclusions.

[2] Both the first ambulacral articulation bar and the proximal ossicle tip are missing in the available orals of *Cistina* on which the drawings are based; see remarks under Materials and Methods.

Note added in proof.—Tortonese and Downey (1977) have revived the generic name *Othilia* Gray for those species previously assigned to *Echinaster* that bear glassy tubercles on the primary ossicles of the surface (e.g., abactinals, marginals). *O. modestus*, discussed here under *Echinaster*, is included in this group.

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